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VOL. LVI SEPTEMBER 29, 1922 NO. 1448

CONTENTS

SOME ASPECTS OF ANIMAL MECHANISM[1]

IT is sometimes said that science lives too much in itself, but once a year it tries to remove that reproach. The British Association meeting is that annual occasion, with its opportunity of talking in wider gatherings about scientific questions and findings. Often the answers are tentative. Commonly questions most difficult are those that can be quite briefly put. Thus, "Is the living organism a machine?" "Is life the running of a mechanism?" The answer cannot certainly be as short as the question. But let us, in the hour before us, examine some of the points it raises.

Of course for us the problem is not the "why" of the living organism but the "how" of its working. If we put before ourselves some aspects of this working we may judge some at least of the contents of the question. It might be thought that the problem is presented at its simplest in the simplest forms of life. Yet it is in certain aspects more seizable in complex animals than it is in simpler forms.

Our own body is full of exquisite mechanism. Many exemplifications could be chosen. There is the mechanism by which the general complex internal medium, the blood, is kept relatively constant in its chemical reaction, despite the variety of the food replenishing it and the fluctuating draft from and input into it from various organs and tissues. In this mechanism the kidney cells and the lung cells form two of the main sub-mechanisms. One part of the latter is the delicate mechanism linking the condition of the air at the bottom of the lungs with that particular part of the nervous system which manages the ventilation of the lungs. On that ventilation depends the

[1] Presidential address delivered at the Hull meeting of the British Association on September 6.

proper respiratory condition of the blood. The nervous center which manages the rhythmic breathing of the chest is so responsive to the respiratory state of the blood supplied to itself that, as shown by Drs. Haldane and Priestley some years ago, the very slightest increase in the partial pressure of carbon dioxide at the bottom of the lungs at once suitably increases the ventilation of the chest. Dovetailed in with this mechanism is yet another working for adjustment in the same direction. As the lung is stretched by each inbreath the respiratory condition of the nervous center, already attuned to the respiratory quality of the air in the lungs, sets the degree to which inspiration shall fill them ere there ensue the opposite movement of outbreath. All this regulation, although the nervous system takes part in it, is a mechanism outside our consciousness. Part of it is operated chemically; part of it is reflex reaction to a stimulus of mechanical kind, though as such unperceived. The example taken has been nervous mechanism. If, in the short time at our disposal, we confine our examples to the nervous system, we shall have the advantage that in one respect that system presents our problem possibly at its fullest.

To turn therefore to another example, mainly nervous. Muscles execute our movements; they also maintain our postures. This postural action of muscles is produced by nerve-centers which form a system more or less their own. One posture of great importance thus maintained is that of standing, the erect posture. This involves due cooperation of many separate muscles in many parts. Even in the absence of those portions of the brain to which consciousness is adjunct, the lower nerve-centers successfully bring about and maintain the cooperation of muscles which results in the erect posture; for example, the animal in this condition, if set on its feet, stands. It stands reflexly; more than that, it adjusts its standin posture to required conditions. If the pose of one of the limbs be shifted a compensatory shift in the other limbs is induced, so that stability is retained. A turn of the creature's neck sidewise and the body and limbs, of themselves, take up a fresh attitude appropriate to the side-turned head. Each particular pose of the neck telegraphs off to the limbs and body a particular posture required from them, and that posture is then maintained so long as the neck posture is maintained. Stoop the creature's neck and the forelimbs bend down as if to seek something on the floor. Tilt the muzzle upward and the forelimbs straighten and the hind limbs crouch as if to look at something on a shelf. Purely reflex mechanism provides all kinds of ordinary postures.

Mere reflex action provides these harmonies of posture. The nerve-centers evoke for this purpose in the required muscles a mild, steady contraction, with tension largely independent of the muscle length and little susceptible to fatigue. Nerve-fibers run from muscle to nerve-center, and by these each change in tension or length of the muscle is reported to the activating nerve-center. They say "tension rising, you must slacken," or conversely. There are also organs the stimulation of which changes with any change of their relation to the line of gravity. Thus, a pair of tiny water-filled bags is set one in each side of the skull and in each is a patch of cells endowed with a special nerve. Attached to hairlets of these cells is a tiny crystalline stone the pressure of which acts as a stimulus through them to the nerve. The nerve of each gravity-bag connects, through chains of nerve-centers, with the muscles of all the limbs and of one side of the neck. In the ordinary erect posture of the head, the stimulation by the two bags right and left is equal, because the two gravity-stones then lie symmetrically. The result, then, is a symmetrical muscular effect on the two sides of the body, namely, the normal erect posture. But the right and left bags are mirror pictures of each other. If the head incline to one side, the resulting slip, microscopic though it be, of the two stones on their nerve-patches makes the stimulation unequal. From that slip there results exactly the right unsymmetrical action of the muscles to give the unsymmetrical pose of limbs and neck required for stability. That is the mechanism dealing with limbs and trunk and neck. An additional one postures the head itself on the neck. A second pair of tiny gravity-bags, in

which the stones hang rather than press, are utilized. These, when any cause inclining the head has passed, bring the head back at once to the normal symmetry of the erect posture. These same bags also manage the posturing of the eyes. The eye contributes to our orientation in space; for example, to perception of the vertical. For this the eyeball, that is the retina, has to be postured normally, and the pair of little gravity-bags in the skull, which serve to restore the head posture, act also on the eyeball muscles. Whichever way the head turns, slopes, or is tilted, they adjust the eyeball's posture compensatingly, so that the retina still looks out upon its world from an approximately normal posture, retaining its old verticals and horizontals. As the head twists to the right the eyeball's visual axis untwists from the right. These reactions of head, eyes and body unconsciously take place when a bird wheels or slants in flight or a pilot stalls or banks his areoplane; and all this works itself involuntarily as a pure mechanism.

True, in such a glimpse of mechanism what we see mainly is how the machinery starts and what finally comes out of it; of the intermediate elements of the process we know less. Each insight into mechanism reveals more mechanism still to know. Thus, scarcely was the animal's energy balance in its bearing upon food intake shown comfortably to conform with thermodynamics than came evidence of the so-called "vitamins"—evidence showing an unsuspected influence on nutrition by elements of diet taken in quantities so small as to make their mere calorie value quite negligible; thus, for the growing rat, to quote Professor Harden, a quantity of vitamin A of the order of one five-hundredths milligram a day has potent effect. Again, as regards sex determination, the valued discovery of a visible distinction between the nuclear threads of male and female brings the further complexity that, in such cases, sex extends throughout the whole body to every dividing cell. Again, the asssociation of hereditary unit-factors, such as body color or shape of wing, to visible details in the segmenting nucleus seemed to simplify by epitomizing. But further insight tends to trace the inherited unit character not to the chromosome itself, but to balance of action between the chromosome group. As with the atom in this heroic age of physicists, the elementary unit once assumed simple proves, under further analysis, to be itself complex. Analysis opens a vista of further analysis required. Knowledge of muscle contraction has, from the work of Fletcher and Hopkins on to Hill, Hartree, Meyerhof and others, advanced recently more than in many decades heretofore. The engineer would find it difficult to make a motive machine out of white of egg, some dissolved salts, and thin membrane. Yet this is practically what nature has done in muscle, and obtained a machine of high mechanical efficiency. Perhaps human ingenuity can learn from it. One feature in the device is alternate development and removal of acidity. The cycle of contraction and relaxation is traced to the production of lactic acid from glycogen and its neutralization chiefly by alkaline proteins; and physically to an admirably direct transition from chemical to mechanical effect. What new steps of mechanism all this now opens!

But knowledge, while making for complexity, makes also for simplification. There seems promise of simplification of the mechanism of reflex action. Reflex action with surprising nicety calls into play just the appropriate muscles, and adjusts them in time and in the suitable grading of their strength of pull. The moderating as well as the driving of muscles is involved. Also the muscles have to pass from the behest of one stimulus to that of another, even though the former stimulus still persist. For these gradings, coadjustments, restraints, and shifts, various separate kinds of mechanism were assumed to exist in the nerve-centers, although of the nature of such mechanisms little could be said. Their processes were regarded as peculiar to the nerve-centers and different from anything that the simple fibers of nerve-trunks outside the centers can produce. We owe to Lucas and Adrian the demonstration that, without any nerve-center whatever, an excised nerve-trunk with its muscle attached can be brought to yield, besides conduction of nerve impulses, the grading of them. That is remarkable, because the

impulse is not gradable by grading the strength of the stimulus. The energy of the impulse comes not from the stimulus, but from the fiber itself. But Lucas and Adrian have shown, however, that it is gradable in another way. Though the nerve impulse is a very brief affair—it lasts about one thousandths second at any one point of the nerve—it leaves behind it in the nerve-fiber a short phase during which the fiber cannot develop a second impulse. Then follows rapid but gradual recovery of the strength of impulse obtainable from the fiber. That recovery may swing past normal to supernormal before returning finally to the old resting state. Hence, by appropriately timing the arrival of a second impulse after a first, that second impulse may be extinguished, reduced, increased or transmitted without alteration. This property of grading impulses promises a complete key to reflex action if taken along with one other. The nervous system, including its centers, consists of nothing but chains of cells and fibers. In these chains the junctions of the links appear to be points across which a large impulse can pass, though a weak one will fail. At these points the grading of impulses by the interference process just outlined can lead, therefore, to narrowing or widening their further distribution, much as in a railway system the traffic can be blocked or forwarded, condensed or scattered. Thus the distribution and quantity of the muscular effect can be regulated and shifted not only from one muscle to another, but in one and the same muscle it can be graded by adding to or subtracting from the number of fibers activated within that muscle. As pointed out by Professor Alexander Forbes, it may be, therefore, that the nerve impulse is the one and only reaction throughout the whole nervous system, central and peripheral,—trains of impulses colliding and over-running as they travel along the conductive network. In this may lie the secret of the coordination of reflexes. The nerve-center seems nothing more than a meeting-place of nerve-fibers, its properties but those of impulses in combination. Fuller knowledge of the mechanism of the nervous impulse, many of the physical properties of which are now known, a reaction which can be studied in the simplest units of the nervous system, thus leads to a view of nervous function throughout the system much simpler than formerly obtained.

Yet for some aspects of nervous mechanism the nerve impulse offers little or no clue. The fibers of nerve-trunks are, perhaps, of all nerve-structures those that are best known. They constitute, for example, the motor nerves of muscle and the sensory nerves of the skin. They establish their ties with muscle and skin during embryonic life and maintain them practically unaltered throughout the individual's existence, growing no further. If severed, say, by a wound, they die for their whole length between the point of severance and the muscle or skin they go to. Then at once the cut ends of the nerve-fibers start regrowing from the point of severance, although for years they have given no sign of growth. The fiber, so to say, tries to grow out to reach to its old far-distant muscle. There are difficulties in its way. A multitude of non-nervous repair cells growing in the wound spin scar tissue across the new fiber's path. Between these alien cells the new nerve-fiber threads a tortuous way, avoiding and never joining any of them. This obstruction it may take many days to traverse. Then it reaches a region where the sheath-cells of the old dead nerve-fibers lie altered beyond ordinary recognition. But the growing fiber recognizes them. It joints them and, tunneling through endless chains of them, arrives finally, after weeks or months, at the wasted muscle-fibers which seem to have been its goal, for it connects with them at once. It pierces their covering membranes and reforms with their substance junctions of characteristic pattern resembling the original that had died weeks or months before. Then its growth ceases, abruptly, as it began, and the wasted muscle recovers and the lost function is restored.

Can we trace the causes of this beneficent yet so unaccountable reaction? How is it that severance can start the nerve re-growing. How does the nerve-fiber find its lost muscle microscopically miles away? What is that mechanism that drives and guides it? Is it a chemotaxis like that of the antherozooid in the botanical experiment drawn towards the focus of the

dissolved malic acid? If so, there must be a marvelously arranged play of intricate sequences of chemically attractive and repellent substances dissolved suitably point to point along the tissue. It has recently been stated that the nerve-fiber growing from a nerve-cell in a nutrient field of graded electrical potential grows strictly by the axis of the gradient. Some argue for the existence of such potential gradients in the growing organism. Certainly nerve regeneration seems a return to the original phase of growth, and pieces of adult tissue removed from the body to artificial nutrient media in the laboratory take on vigorous growth. Professor Champy describes how epithelium that in the body is not growing, when thus removed starts growing. If freed from all fibrous tissue, its cells not only germinate, but, as they do so, lose their adult specialization. In nerve regeneration the nerve-sheath cells, and to some extent the muscle-cells which have lost their nerve-fiber, lose likewise their specialized form, and regain it only after touch with the nerve-cell has been re-established. So similarly epithelium and its connective tissue cultivated outside the body together both grow and both retain their specialization. The evidence seems to show that the mutual touch between the several cells of the body is decisive of much in their individual shaping and destiny. The severance of a nerve-fiber is an instance of the dislocation of such a touch. It recalls well-known experiments on the segmenting egg. Destruction of one of the two halves produced by the first segmentation of the egg results in a whole embryo from the remaining half-egg; but if the two blastomeres, though ligated, be left side by side, each then produces a half-embryo. Each half-egg *can* yield a whole embryo, but is restrained by the presence of the twin cell to yielding but a half embryo. The nerve severance seems to break a mutual connection which restrained cell growth and maintained cell differentiation.

It may be said that the nerve-sheath cells degrade because the absence of transmission of nerve impulses leaves their fiber functionless. But they do not degrade in the central nerve-piece, although impulses no longer pass along the afferent fibers. This mechanism of reconstruction seems strangely detached from any direct performance of function. The sprouting nerve-fibers of a motor nerve with impulses for muscular contraction can by misadventure take their way to denervated skin instead of muscle. They find the skin-cells the nerve-fibers of which have been lost, and on these they bud out twigs, as true sensory fibers would do. Then, seemingly satisfied by so doing, they desist from further growth. The sense-cells, too, after this misunion, regain their normal features. But this joining of motor nerve-fiber with sense-cell is functionless, and must be so because the directions of functional conduction of the two are incompatible. Similarly a regenerating skin-nerve led down to muscle makes its union with muscle instead of skin, though the union is a functional misfit and can not subserve function. Marvelous though nerve regeneration be its mechanism seems blind. Its vehemence is just as great after amputation, when the parts lost can of course never be re-reached. Its blindness is sadly evident in the suffering caused by the useless nerve-sprouts entangled in the scar of a healing or healed limb-stump.

There is a great difference, however, between the growth of such regeneration and the growth impulse in pieces of tissue isolated from the body and grown in media outside. With pure cultures, in the latter case, Professor Champy says the growth recalls in several features that of malignant tumors, for example, multiplication of cells unaccompanied by formation of a specialized adult tissue. A piece of kidney cultivated outside the body de-differentiates, to use his term, into a growing mass unorganized for renal function. But with connective-tissue cells added even breast-cancer epithelium will in cultivation grow in glandular form. New ground is being broken in the experimental control of tissue growth. The report of the Imperial Cancer Research Fund mentions that in cultivation outside the body malignant cells present a diffculty that normal cells do not. To the malignant cells the nutrient soil has to be renewed more frequently, because they seem rapidly to make the soil in which they grow poisonous to themselves,

though not to normal cells. The following of all clues of difference between the mechanism of malignant growth and of normal is fraught with importance which may be practical as well as theoretical.

The regenerating nerve rebuilds to a plan that spells for future function, but throughout all its steps prior to the time when it actually reaches the muscle or skin, no actual performance of nerve-function can take place. What is constructed is functionally useless until the whole is complete. So similarly with much of the construction of the embryo in the womb for purposes of a different life after emergence from the womb; of the lung for air-breathing after birth; of the reflex contraction in the fœtal child of the eyelids to protect the eye long before the two eyelids have been separated, let alone ere hurt or even light can reach it; of the butterfly's wing within the chrysalis for future flight. The nervous system in its repair, as in its original growth, shows us a mechanism working through phases of non-functioning preparation in order to forestall and meet a future function. It is a mechanism against the seeming prescience of which is to be set its fallibility and its limitations. The "how" of its working is at present chiefly traceable to us in the steps of its results rather than in comprehension of its intimate reactions; as to its mechanism, perhaps the point of chief import for us here is that those who are closest students of it still regard it as a mechanism. If "to know" be "to know the causes" we must confess to want of knowledge of how its mechanism is contrived.

If we knew the whole "how" of the production of the body from egg to adult, and if we admit that every item of its organic machinery runs on physical and chemical rules as completely as do inorganic systems, will the living animal present no other problematical aspect? The dog, our household friend—do we exhaust its aspects if in assessing its sum-total we omit its mind? A merely reflex pet would give little pleasure even to the fondest of us. True, our acquaintance with other mind than our own can only be by inference. We may even hold that mind as an object of study does not come under the rubric of natural science at all. But this association has its section of psychology, and my theme of to-night was chosen partly at the suggestion of a late member of it, Dr. Rivers, the loss of whom we all deplore. As a biologist he viewed mind as a biological factor. Keeping mind and body apart for certain analytic purposes must not allow us to forget their being set together when we assess as a whole even a single animal life.

Taking as manifestations of mind those ordinarily received as such, mind does not seem to attach to life, however complex, where there is no nervous system, nor even where that system, though present, is little developed. Mind becomes more recognizable the more the nerve-system is developed; hence the difficulty of the twilit emergence of mind from no mind, which is repeated even in the individual life history. In the nervous system there is what is termed localization of function—relegation of different works to the system's different parts. This localization shows mentality, in the usual acception of that term, not distributed broadcast throughout the nervous system, but restricted to certain portions of it; for example, among vertebrates to what is called the forebrain, and in higher vertebrates to the relatively newer parts of that forebrain. Its chief, perhaps its sole, seat is a comparatively modern nervous structure superposed on the non-mental and more ancient other nervous parts. The so-to-say mental portion of the system is placed so that its commerce with the body and the external world occurs only through the archaic non-mental remainder of the system. Simple nerve impulses, their summations and interferences, seem the one uniform office of the nerve-system in its non-mental aspect. To pass from a nerve impulse to a psychical event, a sense-impression, percept, or emotion is, as it were, to step from one world to another and incommensurable one. We might expect, then, that at the places of transition from its non-mental to its mental regions the brain would exhibit some striking change of structure. But it is not so; in the mental parts of the brain there is nothing but the same old structural elements, set end to end, suggesting the one function of the transmission and collision of nerve impulses. The structural inter-connections are richer, but that is merely a quantitative change.

I do not want, and do not need, to stress our inability at present to deal with mental actions in terms of nervous actions, or *vice versa.* Facing the relation borne in upon us as existent between them, however, may we not gain some further appreciation of it by reminding ourselves even briefly of certain points of contact between the two? Familiar as such points are, I will mention rather than dwell upon them.

One is the so-called expression of the emotions. The mental reaction of an emotion is accompanied by a nervous discharge which is more or less characteristic for each several type of emotion, so that the emotion can be read from its bodily expression. This nervous discharge is involuntary, and can affect organs, such as the heart, which the will can not reach. Then there is the circumstance that the peculiar ways and tricks of the nervous machinery as revealed to us in the study of mere reflex reactions repeat themselves obviously in the working of the machinery to which mental actions are adjunct. The phenomenon of fatigue is common to both, and imposses similar disabilities on both. Nervous exhaustion and mental exhaustion mingle. Then, as offset against this disability, there exists in both the amenability to habit formation, mere repetition within limits rendering a reaction easier and readier. Then, and akin to this, is the oft-remarked trend in both for a reaction to leave behind itself a trace, an engram, a memory, the reflex engram, and the mental memory.

How should inertia and momentum affect non-material reactions? Quick though nervous reactions are, there is always easily observed delay between delivery of stimulus and appearance of the nervous end effect; and there is always the character that a reaction once set in motion does not cease very promptly. Just the same order of lag and overrun, of want of dead-beat character, is met in sense-reactions. The sensation outlives the light which evoked it, and the stronger the reaction the longer the sensation persists. Similarly the reflex after-discharge persists after the stimulus is withdrawn and subsides more slowly the stronger the reaction. The times in both are of the same order. Again, a reflex act which contracts one muscle commonly relaxes another. Even so, with rise of sensation in one part of the visual field commonly occurs lapse of sensation in another. The stoppage is in both by inhibition, that is to say, active. Then again, two lights of opposite color falling simultaneously and correspondingly on the two retinæ will, according to their balance, fuse to an intermediate tint or see-saw back and forth between the one tint and the other. Similarly a muscle impelled by two reflexes, one tending to contract it, the other to relax it, will, according to the balance of the reflexes, respond steadily with an intensity which is a compromise between the two, or see-saw rhythmically from extreme to extreme of the two opposite influences.

Reflex acts commonly predispose to their opposites; thus the visual impression of one color predisposes to that of its opposite. Again, the *position* of the stimulated sensual point acts on the mind—hence the light seen or the pain felt is referred to some locus in the mind's space-system. Similarly the reflex machinery directs, for example, the limb it moves towards the particular spot stimulated. Such spots in the two processes, mental and non-mental, correspond.

Characteristic of the nervous machinery is its arrangement in what Hughlings Jackson called "levels," the higher levels standing to the lower not only as drivers but also as restrainers. Hence in disease underaction of one sort is accompanied by overaction of another. Thus in the arm affected by a cerebral stroke, besides loss of willed—that is higher level—power in the finger muscles, there is in other muscles involuntary overaction owing to escape of lower centers from control by the higher which have been destroyed. Similarly with the sensory effects; of skin sensations some are painful and some not, for example, touch. The seat of the latter is of higher level, cortical; of the former lower, sub-cortical. When cerebral disease breaks the path between the higher and the underlying level a result is impairment of touch sensation but heightening of pain sensation in the affected part. The sensation of touch, as Dr. Head says, restrains that of pain.

Thus features of nervous working resemble over and over again mental activities. Is it mere metaphor, then, when we speak of mental

attitudes as well as bodily? Is it mere analogy to liken the warped attitude of the mind in a psychoneurotic sufferer to the warped attitude of the body constrained by an internal potential pain? Again, some mental events seem spontaneous; in the nervous system some impulses seem generated automatically from within.

It may be said of all these similarities of time-relation and the rest between the ways of the nervous system and such simpler ways of mind as I here venture on, that they exist because the operations of the mental part of the nervous system communicate with the exterior only through the non-mental part as gateway, and that there the features of the nerve-machinery are impressed on the mind's working. But that suggestion does not take into account the fact that the higher and more complex the mental process, the longer the time-lag, the more incident the fatigue, the more striking the memory character, and so on.

All this similarity does but render more succinct the old enigma as to the nexus between nerve impulse and mental event. In the proof that the working of the animal mechanism conforms with the first law of thermodynamics is it possible to say that psychical events are evaluated in the balance sheet drawn up? On the other hand, Mr. Barcroft and his fellow-observers in their recent physiological exploration of life on the Andes at 14,200 feet noted that their arithmetic as well as their muscles were at a disadvantage; the low oxygen pressure militated against both. Indeed, we all know that a few minutes without oxygen, or few more with chloroform, and the psychical and the nervous events will lapse together. The nexus between the two sets of events is strict, but for comprehension of its nature we still require, it seems, comprehension of the unsolved mystery of the "how" of life itself. A shadowy bridge between them may lie perhaps in the reflection that for the observer himself the physical phenomena he observes are in the last resort psychical.

The practical man has to accept nervous function as a condition for mental function without concerning himself about ignorance of their connection. We know that with structural derangement or destruction of certain parts of the brain goes mental derangement or defect, while derangement or destruction of other parts of the nervous system is not so accompanied. Decade by decade the connection between certain mental performances and certain cerebral regions becomes more definite. Certain impairments of ideation as shown by forms of incomprehension of language or of familiar objects can help to diagnose for the surgeon that part of the brain which is being compressed by a tumor, and the tumor gone the mental disabilities pass. Similarly those who, like Professor Elliot Smith and Sir Arthur Keith, recast the shape of the cerebrum from the cranial remains of prehistoric man, can outline for us something of his mentality from examination of the relative development of the several brain regions, using a true and scientific phrenology.

Could we look quite naïvely at the question of a seat for the mind within the body we might perhaps suppose it diffused there, not localized in any one particular part at all. That it is localized and that its localization is in the nervous system—can we attach meaning to that fact? The nervous system is that bodily system the special office of which, from its earliest appearance onward throughout evolutionary history, has been more and more to weld together the body's component parts into one consolidated mechanism reacting as a unity to the changeful world about it. More than any other system it has constructed out of a collection of organs an individual of unified act and experience. It represents the acme of accomplishment of the integration of the animal organism. That it is in this system that mind, as we know it, has had its beginning, and with the progressive development of the system has developed step for step, is surely significant. So it is that the portion in this system to which mind transcendently attaches is exactly that where are carried to their highest pitch the nerve-actions which manage the individual as a whole, especially in his reactions to the external world. There, in the brain, the integrating nervous centers are themselves further compounded, inter-connected, and re-combined for unitary functions. The cortex of the fore-

brain is the main seat of mind. That cortex with its twin halves corresponding to the two side-halves of the body is really a single organ knitting those halves together by a still further knitting together of the nervous system itself. The animal's great integrating system is there still further integrated and this supreme integrator is the seat of all that is most clearly inferable as the animal's mind. As such it has spelt biological success to its possessors. From small beginnings it has become steadily a larger and larger feature of the nervous system, until in adult man the whole remaining portion of the system is relatively dwarfed by it. It is not without significance, perhaps, that in man this organ, the brain cortex, bifid as it is, shows unmistakable asymmetry. Man is a tool-using animal, and tools demand asymmetrical, though attentive and therefore unified, acts. A nervous focus unifying such motor function will, in regard to a laterally bipartite organ, tend more to one half or the other and in man's cerebrum the preponderance of one half, namely, the left, over the other may be a sign of unifying function.

It is to the psychologist that we must turn to learn in full the contribution made to the integration of the animal individual by mind. But each of us can recognize, without being a professed psychologist, one achievement in that direction which mental endowment has produced. Made up of myriads of microscopic cell-lives, individually born, feeding and breathing individually within the body, each one of us nevertheless appears to himself a single entity, a unity experiencing and acting as one individual. In a way the more far-reaching and many-sided the reactions of which a mind is capable the more need, as well as the more scope, for their consolidation to one. True, each one of us is in some sense not one self, but a multiple system of selves. Yet how closely those selves are united and integrated to one personality. Even in those extremes of so-called double personality one of their mystifying features is that the individual seems to himself at any one time wholly either this personality or that, never the two commingled. The view that regards hysteria as a mental dissociation illustrates the integrative trend of the total healthy mind. Circumstances can stress in the individual some, perhaps lower, instinctive tendency that conflicts with what may be termed his normal personality. This latter, to master the conflicting trend, can judge it in relation to his main self's general ethical ideals and duties to self and the community. Thus intellectualizing it, he can destroy it or consciously subordinate it to some aim in harmony with the rest of his personality. By so doing there is gain in power of will and in personal coherence of the individual. But if the morbid situation be too strong or the mental self too weak, instead of thus assimilating the contentious element the mind may shun and, so to say, endeavor to ignore it. That way lies danger. The discordant factor escaped from the sway of the conscious mind produces stress and strain of the conscious self; hence, to use customary terminology, dissociation of the self sets in, bringing in its train those disabilities, mental or nervous or both, which characterize the sufferer from hysteria. The normal action of the mind is to make up from its components one unified personality. When we remember the manifold complexity of composition of the human individual, can we observe a greater example of solidarity of working of an organism than that presented by the human individual, intent and concentrated, as the phrase goes, upon some higher act of strenuous will? Physiologically the supreme development of the brain, psychologically the mental powers attaching thereto, seem to represent from the biological standpoint the very culmination of the integration of the animal organism.

The mental attributes of the nervous system would be, then, the coping-stone of the construction of the individual. Surveyed in their broad biological aspect, we see them carrying integration even further still. They do not stop at the individual; they proceed beyond the individual; they integrate, from individuals, communities. When we review, so far as we can judge it, the distribution of mind within the range of animal forms, we meet two peaks of its development—one in insect life, the other in the vertebrate, with its acme finally in man. True, in the insect the type of mind is not

rational but instinctive, whereas at the height of its vertebrate development reason is there as well as instinct. Yet in both one outcome seems to be the welding of individuals into societies on a scale of organization otherwise unattained. The greatest social animal is man and the powers that make him so are mental; language, tradition, instinct for the preservation of the community, as well as for the preservation of the individual, reason actuated by emotion and sentiment, and controlling and welding egoistic and altruistic instincts into one broadly harmonious, instinctive-rational behavior. Just as the organization of the cell-colony into an animal individual receives its highest contribution from the nervous system, so the further combining of animal individuals into a multi-individual organism, a social community, merging the interests of the individual in the interests of the group, is due to the nervous system's crowning attributes, the mental. That this integration is still in process, still developing, is obvious from the whole course of human pre-history and history. The biological study of it is essentially psychological; it is the scope and ambit of social psychology. Not the least interesting and important form of social psychology is that relatively new one, dealing with the stresses and demands that organized industry makes upon the individual as a unit in the community of our day and with the readjustments it asks from that community.

To resume, then, we may, I think, conclude that in some of its aspects animal life presents to us mechanism the "how" of which, despite many gaps in our knowledge, is fairly explicable. Of not a few of the processes of the living body, such as muscular contraction, the circulation of the blood, the respiratory intake and output by the lungs, the nervous impulse and its journeyings, we may fairly feel, from what we know of them already, that further application of physics and chemistry will furnish a competent key. We may suppose that in the same sense as we can claim to-day that the principles of a gas-engine or an electromotor are comprehensible, so will the bodily working in such mechanisms be understood by us, and indeed are largely so already. It may well be possible to understand the principle of a mechanism which we have not the means or skill ourselves to construct; for example, we cannot construct the atoms of a gas-engine.

Turning to other aspects of animal mechanism, such as the shaping of the animal body, the conspiring of its structural units to compass later functional ends, the predetermination of specific growth from egg to adult, the predetermined natural term of existence, these and their intimate mechanism, we are, it seems to me, despite many brilliant inquiries and inquirers, still at a loss to understand. The steps of the results are known, but the springs of action still lie hidden. Then again, the "how" of the mind's connexion with its bodily place seems still utterly enigma. Similarity or identity in time-relations and in certain other ways between mental and nervous processes does not enlighten us as to the actual nature of the connexion existing between the two. Advance in biological science does but serve to stress further the strictness of the nexus between them.

Great differences of difficulty therefore confront our understanding of various aspects of animal life. Yet the living creature is fundamentally a unity. In trying to make the "how" of an animal existence intelligible to our imperfect knowledge we have, for purposes of study, to separate its whole into part-aspects and part-mechanisms, but that separation is artificial. It is as a whole, a single entity, that the animal, or for that matter the plant, has finally and essentially to be envisaged. We cannot really understand one part without the other. Can we suppose a unified entity which is part mechanism and part not? One privilege open to the human intellect is to attempt to comprehend, not leaving out of account any of its properties, the "how" of the living creature as a whole. The problem is ambitious, but its importance and its reward are all the greater if we seize and attempt the full width of its scope. In the biological synthesis of the individual it is concerned with mind. It includes examination of man himself as acting under a biological trend and process which is

combining individuals into a multi-individual organization, a social organism surely new in the history of the world. This biological trend and process is constructing a social organism the cohesion of which depends mainly on a property developed so specifically in man as to be, broadly speaking, his alone, namely, a mind actuated by instincts but instrumented with reason. Man, often Nature's rebel, as Sir Ray Lankester has luminously said, can, viewing this great supra-individual process, shape his courses conformably with it even as an individual, feeling that in this case to rebel would be to sink lower rather than to continue his own evolution upward.

C. S. SHERRINGTON

CAN WASTE OF MENTAL EFFORT BE AVOIDED

ONE of the most startling phenomena in the history of science and invention is the lack of economy of mental effort. As a rule the great discoveries in science have not been made once, but have been repeated several times. It is as though engineers had built several Panama canals when only one was needed, thereby producing financial waste. At the recent death of Alexander Graham Bell the daily press reminds us that he invented the telephone. But he was not the only one who accomplished this. On the very day that Bell patented his telephone, Elisha Gray applied for a patent for an instrument of similar kind. At an earlier date Phillip Reis sent a speaking machine to the emperor of Russia. The same is true in the invention of the telegraph. No historian of science can give Samuel Morse exclusive credit. Before him, Joseph Henry at Albany, by the attraction of an electromagnet, produced audible signals at a distance. Gauss and Weber sent messages by an electromagnetic device over wires connecting the Observatory and Physical Cabinet at Göttingen. The mental effort of inventing the telegraph and telephone was made, not once, but several times.

These are only two of the numerous illustrations which might be given of duplication in applied science. In pure science the situation is even worse. Waste of effort through repetition occurred in the discovery of the laws of gases, Ohm's law in electricity, the principle of the conservation of energy, logarithms, determinants, J. W. Gibb's equilibrium of chemical systems and Mendel's law. The full accounts of reproduction of scientific discovery and invention would fill a large book. The waste of gray matter has resembled the prodigality of the pine-tree which produces millions of pollen particles for every new plant that is actually started.

It may be argued that the waste occurs only in the records of centuries which are passed, that the number of scientific journals has now increased so greatly that scientific results can be published promptly. As a matter of fact, the greater number of journals has not brought effective relief. The danger of unnecessary repetition is still with us. Not only is the army of scientific workers tremendously augmented, so that even now the editorial desks are overloaded with able manuscripts and publication is not so prompt as some suppose, but the long list of scientific journals has greatly augmented the labor on the part of any one worker to ascertain what new results have been reached in his particular field of activity. Paradoxical as it may seem, the publications themselves, by their great mass, clog the worker's efforts to find what he desires.

It is still true that investigators are frequently unacquainted with results already reached by others. And so it frequently happens that the best brains are exercised to the utmost in discovering things already discovered by others. Creative genius is rare. There are in a generation few cubic decimeters of brains in a nation, capable of materially advancing science, and yet history shows that in the past a large part of these precious cubic decimeters of gray matter has been expended upon needless repetition.

Is it not possible to improve on the present wasteful methods of conducting research? There is indeed need of persistence in the endeavor that

No subtle, bright and novel thought
In this wide world shall come to naught;
No germ of purest ray serene
Shall scintillate by us unseen.

Can the pathfinders of the intellect conduct their inquiries as if organized in a team for a relay race, each individual carrying the torch of light from the point reached by his predecessor? Such a procedure would prevent repetition. But unfortunately the problem before us is too complex to admit of such simple solution. The impracticability of the relay plan is evident from the consideration that when A has announced some startling novelty, not only B, but also C, D and E may take up the further pursuit of the subject. And it is indeed well that it should be so, for not every B, C, D and E may be fortunate to travel in the right direction and reach desired results. The probability of further penetration into the unknown is increased when several able minds are at work simultaneously, rather than one alone. Moreover, several workers may expect to obtain a greater volume of new knowledge. Under these circumstances some duplication is quite certain and can not be avoided. But when a goal has been reached by one or more men, there should be an effective system of distribution of this knowledge that will stop all unnecessary intellectual endeavor.

In the prevention of waste the capitalist can play a leading rôle. A serious difficulty encountered in the United States at the present time is the lack of funds for prompt publication. In mathematics, for example, no new books in advanced fields have been issued in this country in recent years. Several manuscripts are awaiting publication. Moreover, the American periodicals devoted to research articles are financially unable to print articles except after long delay. Terminal stations for the distribution of scientific products are greatly congested. Moreover, there is a crying need for efficient and prompt bibliography and abstracts of scientific output. It is here that the sympathetic capitalist can contribute to the advancement of science almost as much as he could, were he himself one of the foremost research workers. He can contribute to a very essential phase of scientific progress, namely, the prompt distribution of new knowledge and the prevention of avoidable waste of effort. Essential agencies in the dissemination of knowledge are abstracts and bibliographies. Except in chemistry and medicine, the United States has been derelict in the discharge of its share of obligation in this regard. The Great War has disarranged what was being accomplished in Europe and the present international situation is much worse than that of eight years ago.

The need of the hour is not only adequate funds for printing, but also new, more instantaneous and effective methods of distribution. Some advance is desired which will accomplish for the twentieth century what the invention of printing achieved for the fifteenth century and photography for the nineteenth century. Scientific discovery should take up as one of its problems its own more efficient progress. Science should bend its efforts to devise new plans to accelerate its own rate of advancement. Is it not possible for progress to be made on the compound interest or the snowball mode of accretion? The printing press will not be superseded, but it should be supplemented by new agencies. The possibilities of the radiophone seem almost unlimited. It can be made to do what it is not yet doing. When John Smith has a new result, it lies theoretically within his power to transmit it instantaneously to his co-workers all over the world. And if such were done, the largest part of the waste of mental effort could be avoided. At present this method lends itself more readily to some fields of science than to others. As yet, it is difficult to see how the "radio" could be effectively used in diffusing advanced mathematics that is expressed, perhaps, in the notation of differential equations or in the Peano symbolism. "Radio" appeals, not to the eye, but to the ear. Moreover, it transmits a message that is not permanent, but vanishes as quick as wink. But, probably even in abstruse mathematics, modes of quick and permanent communication by wireless telegraphy will be found to lie within the range of practicability.

The instantaneous distribution of intelligence in the form of a permanent record will remove all avoidable waste of scientific effort.

FLORIAN CAJORI

UNIVERSITY OF CALIFORNIA

AN INSTITUTE FOR ACOUSTIC RESEARCH

THERE is much to be said against too elaborate an organization of scientific research. We carry our highly prized individualized democracy into our experimental endeavors and shun therein all actual or even apparent control "from above." And this attitude if not carried to an extreme is as it should be. We train our young graduate students, for example, to observe the dependence of their problems on past performances of others while at the same time we encourage them to obtain an orientation in the general history of science. It would not do much harm to go further in the latter direction than we do. But above all we unmistakably teach them also the power of self-reliance and attempt to inculcate in them the sense of aggressive initiative in connection with their problems of investigation. The young possessor of the doctorate is distinctly respectful of historical accomplishment and in that light he envisages the present. But from that point on he dares independently to face what lies before.

That assertiveness, displayed in the mature adventurer after truth as well as in the youthful pioneer, does not gainsay the need of cooperation. The problem in science is the same as that in political government: the individual needs the state, the state needs the union of states, and the union of states needs the world confederacy. So the individual investigator needs the stimulus of his colleagues. This extensive sort of organization we have already abundantly recognized in science in the combination of our specific scientific associations into state academies, sectional conferences, national bodies, and international councils.[1]

The present scope of scientific inquiry is developing to such an extent, however, that this type of extensive cooperation and organization is not the only desirable one, for we have already begun to establish what I should like to call an *intensive* form of scientific organization. To draw a comparison this time with industries in the commercial world, it appears that not only are there associations of insurance companies, of automobile manufacturers, of dry goods merchants, and the like, but between these establishments there are associations that group together only certain interests, *e. g.*, the employment managers, the credit men, the buyers, the salemen, *etc.* So as our scientific knowledge increases and our scientists of various persuasions are beginning to explore contiguous territory, we are finding it necessary to obtain an outlet for our common interests. Physicists, chemists, astronomers and mathematicians may to-day be at work on a kindred group of subjects, but from widely different angles of approach. An intensive cooperation among such workers affords often mutual respect, appreciative understanding of the several points of view, real fellowship, and above all more authentic results. It is noteworthy in this connection that many hospitals are inviting groups of scientists to cooperate in a similar way on specific problems presented in such institutions.

There is one field which to the writer's knowledge has already made pronounced progress in intensive cooperation. This is the field of optics and visual phenomena. The photographic and illuminating industries and professions have for some time enlisted the aid of men from several allied sciences. In one of the largest plants for the manufacture of electric incandescent lamps a physicist, a physiologist, and a psychologist have cooperatively undertaken and completed significant problems. While these problems are rarely conjointly solved, there is ample opportunity for mutual consultation. Illuminating engineers are consulting some of the best trained men psychology has to offer; some are entered as regular members of the staff. One of the largest manufacturing concerns of photographic appliances and supplies employs a group of men representing several sciences including psychology.[2]

[1] Dr. W. R. Whitney, director of the Research Laboratory of the General Electric Company, has ably brought out the international character of research in a brief article entitled, "Science—A World Partnership," published in the *Scientific American*, 127, 1922, 100 (August).

[2] Other instances of cooperative research that

Public attention is just now attracted, moreover, to the field of another sense-department, one which, indeed, has usually followed vision both in historical discussions and genetically in the race, *viz.*, hearing. We have lately witnessed an immense development in the photographic and cinematographic industries; now comes the prospect of an even wider application of wireless telephony. With its problems added to the problems that are already facing us in acoustics, it would be wise, it appears to the writer, to provide a sort of clearing-house for work done in acoustics by the various sciences. There are constantly occurring phases of problems and partial problems that need to be referred to the authority of those whose training and equipment guarantees satisfactory envisagement and promises sound conclusion. Not only would the various sciences have something to contribute to an acoustic symposium, but with closer cooperation, a pace could be set, an impetus given, toward more intensive investigation. With this we do not want the type of overhead organization that will throttle endeavor and spontaneous effort, but we need the kind that will inspire research and provide intelligent aid.

Already there are a considerable number of institutions where work of a highly valuable nature is being done in the auditory field. Some of this is cooperative. The acoustical laboratory at the Case School of Applied Science has become an outstanding post of research under the direction of Professor D. C. Miller. At the State University of Iowa Dean C. E. Seashore has for many years done noteworthy work in supervising research in several branches of the auditory field and has recently enjoyed the cooperation of Professor G. W. Stewart in some of these undertakings. At Harvard the late Professor W. C. Sabine contributed largely to an understanding of the auditory properties of architectural interiors, a problem which Professor F. R. Watson, of the University of Illinois, has also largely and ably devoted his attention. The psychological laboratories of Clark, Cornell, Illinois, Missouri, Ohio State have added considerably to our store of knowledge on the subject, while Professor G. E. Shambaugh, of the University of Chicago, stands among those who have done original work in connection with the physiological theory of audition. The private laboratory of Colonel Fabyan at Geneva, Ill., has busied itself to a large extent with auditory phenomena, and a number of industrial enterprises, like the phonographic laboratories, have carried on investigations allied to their work. This brief résumé is doubtless inadequate but serves to show many of the separately organized establishments in acoustic research.

Some of the problems that would lend themselves advantageously to cooperative investigation are summarized below:

(1) *Sound localization.* Further investigation of intensive and qualitative factors in the binaural ratio as applied to the detection of the direction of the source of tones and noises throughout the ranges of intensity and quality; experimental study of sound localization through all three types of media, gaseous, liquid and solid; phantom sounds; polarized sound.

(2) *Qualitative and quantitative thresholds of sound.* Careful scrutiny of the liminal values for both tones and noise; standardization of intensive units of sound; re-investigation of the upper and lower pitch limits of tone with carefully calibrated instruments.

(3) *The attributes of tone and noise.* Systematic review of the tonal manifold with an empirical attempt at classification of the variable characteristics; distinction between noise and tone; question of vowel tones.

(4) *Consonance and dissonance.* Working out the higher difference and summation tones; further analysis of harmony; question of beat-notes.

occur to the writer are: (1) the Mellon Institute of the University of Pittsburgh; (2) the Research Bureau for Retail Training and the Bureau of Personnel Research, both at the Carnegie Institute of Technology at Pittsburgh; (3) the American Institute of Baking of Chicago, and (4) the newly organized Department of Engineering Research at the University of Michigan. Some of these undertakings are entirely, some only in part, financed by commercial corporations which are interested in the problems investigated. In addition mention should be made of a considerable number of industrial fellowships of various descriptions that are maintained by industrial concerns at our larger universities.

(5) *Membranous sound production and transmission.* Improvement in the fidelity of sound production through telephonic and phonographic reproducers; reduction of inherent membraneous tones and noises; problem of sibilants and aspirates.

(6) *The acoustic qualities of confined areas.* Question of preventing leakage of sound through ventilating systems and wall-supports; reflecting and absorbing qualities of various building materials to be used from time to time; acoustic properties of halls, rooms, etc.; "sound-proof" rooms.

(7) *Auditory theory.* Further investigation of the human auditory mechanism and its pathology; intracranial conduction of sound; tonal gaps and "islands."

Specifically, then, it is the opinion of the writer that there exists in this field a threefold need:

I. There should be a closer affiliation of workers in acoustics. An association of those interested might be assembled under some such title as the American Acoustical Society.

II. A journal with this society as sponsor would become an outlet for the publication of papers on the general topics of acoustics.

III. If in the course of events progress is recorded, an endowment fund should be raised with perhaps industrial assistance for the purpose of erecting a central laboratory or institute where apparatus would become available for precise and intensive work. It would save the expense of multiplying elaborate research pieces in our various laboratories where they frequently lie idle for long periods of time. It might serve further for the exchange and loan of apparatus under a system of adequate guarantee against mishandling and breakage.

A number of our leading men working together at such an institute would not only lend zest to their own endeavors, but would offer a place for the training of younger men in the field. The institute would, moreover, provide for the industries that are concerned in the manufacture of acoustical apparatus a fund of information for their guidance and an attentive and trained "ear" for problems that arise in their practical work.

CHRISTIAN A. RUCKMICK

WELLESLEY COLLEGE

PROPOSED FEDERATION OF AMERICAN BIOLOGICAL SOCIETIES

A CONFERENCE was held in Washington in April, 1922, at which a number of biological organizations were represented, to discuss plans for a federation of American biological societies. This meeting was held in pursuance of instructions given by the several societies at their annual meetings at Toronto and elsewhere in 1921. The Washington conference, after some debate, affirmed its belief in the desirability and feasibility of a federation of biological societies, and adopted a general plan in accordance with which such a federation might be established. An outline of this plan has already been published in this journal[1]. A committee was raised to work out the details of the plan and to prepare a constitution embodying these details.

This committee, which consisted of F. R. Lillie, C. W. Greene, I. F. Lewis, C. E. McClung, A. Franklin Shull, R. W. Thatcher, H. B. Ward, and B. E. Livingston representing the American Association, met in Woods Hole, Massachusetts, August 4 and 5, 1922. Professor Herbert Osborn substituted for Professor Livingston at this meeting.

For its own guidance, after some deliberation, the committee adopted certain fundamental principles upon which, in its opinion, any federation should be based. These principles are stated in the following resolution which was adopted by the committee.

Resolved, That it is the judgment of the society representatives considering the formation of a federation of biological societies that certain principles should be observed in setting up relations with existing organizations. These principles are:

1. The federation should, for its benefit, utilize other organizations in accordance with their nature and purposes.

2. The federation should, on the other hand, so direct its policies and methods as to strengthen the efforts of organizations with which it is affiliated.

3. The federation should avoid unnecessary duplication of effort and expenditure.

[1] SCIENCE, Vol. LVI, p. 184.

The concrete application of these principles in the development of a constitution was one of the principal tasks of the committee. How to use such organizations as the National Research Council and the American Association most effectively and in turn how to be of the greatest service to those organizations in the furtherance of the interests of biological science were problems that elicited much discussion. The committee believes that a satisfactory solution of these problems is contained in the constitution given below. This instrument will be submitted to the various societies for ratification or rejection at their annual meetings late in 1922, and it is important that all members of the biological societies which have been concerned in formulating plans of federation should become familiar with its provisions. The proposed constitution of the federation is as follows:

Proposed Constitution
for a
Federation of American Biological Societies

Article I. Preamble

In view of the existence of many biological societies in America, each preoccupied with its own special affairs and problems, in view of the assured interest of all these societies in the broader and more general aspects of the promotion of biological science, and especially in view of the need for improved means of contact and mutual aid between the pure and the applied branches of biological science, this Federation is established to facilitate constructive and mutually advantageous cooperation among the several special biological societies and to promote the major interests of biology.

Article II. Name

The name of this organization shall be the Federation of American Biological Societies.

Article III. Objects

The objects of the Federation shall be to stimulate investigation in the field of biology, to organize and promote the interests of bibliography and publication, to deal with questions of general interest in the field of biology, and in general to promote the solution of those broad problems which the specialized societies are not in a position to support effectively, and to do anything else which may serve these ends.

Article IV. Membership

Section 1. The membership of the Federation shall be by societies and not by individuals.

Section 2. The original members of the Federation shall be all those organizations that were concerned in the Preliminary Conference on Federation held in Washington, D. C., April 23, 1922, provided that each member society shall officially accept membership in the Federation.

Section 3. Any other organization working in the field of biology may become a member of the Federation upon invitation by the Council of the Federation and acceptance of membership.

Section 4. Any Society may terminate its membership in the Federation by official notification to the Council and completion of its obligations to the Federation.

Article V. Delimitation of Authority

The constituent societies of this Federation retain their complete autonomy.

Article VI. Council

Section 1. The management of the Federation shall be vested in a body to be known as the Council of the Federation of American Biological Societies. Each original member society shall be entitled to be represented in the Council by two representatives that the society may officially designate.

Section 2. The Council shall establish its own organization and enact its own rules and by-laws.

Section 3. The Council shall establish regulations governing the admission of additional organizations to membership in the Federation and shall determine their representation in the Council.

Section 4. The Council shall receive and decide questions referred to it by member societies; it may also independently promote the objects of the Federation.

Section 5. The Council shall act in close cooperation with existing agencies, such as the American Association for the Advancement of Science and the National Research Council.

Section 6. The Council shall appoint an Executive Committee, which shall have such duties and powers as the Council may prescribe.

Section 7. The Council shall appoint a Committee on Bibliography and Publication, with such duties and powers as the Council may prescribe. This committee shall act in cooperation with similar committees that may be appointed by the National Research Council and the American Association for the Advancement of Science.

Section 8. The Council shall arrange places and times for its own meetings. The Council shall assist the American Association for the Advancement of Science in making arrangements for meetings of any member society or group of

member societies, when officially requested by the member societies to do so.

Article VII. Finances

The financial affairs of the Federation shall be controlled by the Council, which may receive and administer funds for the promotion of the purposes of the Federation. The current expenses of the Council shall be met by contributions, and by assessments on member societies. The Council may recommend but not impose such assessments.

Article VIII. Reports

The Council may make an annual report to each of the member societies, setting forth the nature and extent of what has been accomplished by the Federation during the past year, and also pointing out, as far as possible, the general lines along which the activities of the Federation are to be directed during the coming year. The annual report of the Council shall include a financial statement.

Article IX. Amendments

Section 1. Amendments to the Constitution shall require the approval of a majority of the Council and of two-thirds of the member societies.

Section 2. Amendments may originate in member societies or in the Council.

Section 3. Notice of proposed amendments must be presented to the Secretary of the Council and mailed to all members at least one month before the meeting at which they are to be considered by the Council. Notice of approval of any amendment by the Council shall be submitted to the Secretaries of the Societies for action. On receipt of notice of the approval of any amendment by two-thirds of the member societies, the Secretary of the Council shall give notice of its adoption in writing to all member societies.

A. FRANKLIN SHULL,
Secretary of the Executive
Committee *pro. tem.*

SCIENTIFIC EVENTS

BUST OF CHESTER S. LYMAN[1]

MR. CHESTER W. LYMAN, of the class of 1882, Yale College, has presented to the trustees of the Scientific School a portrait bust in marble of his father, the late Professor Chester S. Lyman. This piece of sculpture, made by Mr. James T. Porter, of New York, is a beautiful work of art and the artist has not only succeeded in depicting in the marble a likeness which is striking but has caught the essence of the subject's personality. The bust will stand in the faculty room, where it will perpetuate within the walls of the school not only the features but the spirit as well of one whose life was largely devoted to its welfare during the early years of its struggle for existence.

Chester S. Lyman was one of the early professors in the Sheffield Scientific School, having been appointed as professor of industrial mechanics and physics in 1859. In 1884 his chair was limited to astronomy, physics being made a distinct chair, and Dr. Charles S. Hastings was appointed at that date to fill this position. Professor Lyman was retired as professor emeritus in 1889 and died in 1890.

Dr. Hastings, now professor of physics emeritus, has kindly written the following appreciation of the late Professor Lyman's work:

The admirable portrait bust of the late Professor Chester S. Lyman, presented to the Sheffield Scientific School, gives the welcome opportunity to an old and grateful pupil to record some memories of his enviable place as a teacher.

A most interesting sketch of his remarkably intellectual, and even adventurous, life was printed in *The Popular Science Monthly* of September, 1887, by his son, Chester W. Lyman. The present note may, therefore, best confine itself to somewhat personal reminiscences.

In 1867 an acquaintance began which was of inestimable value to the present writer and which continued until the end of Professor Lyman's life. The kindness with which the freshman was received, the generous manner in which his letters of introduction were accepted, served to establish a friendship which is rarely equaled between teacher and scholar. The teaching was by no means confined to the classroom, but extended even to an unrestricted use of his private observatory and convenient little machine shop.

At that time the equipment of the department of physics was very meager. Notwithstanding this fact, such was the ingenuity of Professor Lyman in making necessary apparatus, his clearness of exposition, his profoundly philosophical feeling for the essentials of science, that there was certainly no better school for the earnest student of physics in the country. It was during this period, or a little earlier, that he invented and constructed his water-wave apparatus, which still seems to me the most perfect and remarkable

[1] From the *Yale Alumni Weekly*.

apparatus ever designed for the explanation of a highly complex phenomenon.

In 1869 Professor Lyman, accompanied by his colleague, the eminent astronomer, Professor Newton, went to Europe to purchase physical and mechanical apparatus from a fund given for that purpose by Peter Collier, of the class of 1861, Yale College. Aside from the requisite and familiar instruments of the physical cabinet not already at command, a remarkably full collection of acoustic apparatus was included. The recent discoveries of Helmholtz in the field of sound sensations had enormously enhanced the interest of physicists in that of acoustics, and Professor Lyman utilized this portion of the equipment not only in the classroom but also in a number of public lectures. It was in these lectures that he first made public his ingenious apparatus for compounding pendulum motions at right angles to each other. The enthusiasm with which his audiences received his clear expositions and admirably chosen illustrative experiments left an enduring impression on the memory of his assistant.

A mind so richly stored with the experiences of a singularly varied life could not be otherwise than stimulating in the highest degree to his more thoughtful students, but more than any other teacher known to the writer he awakened a personal affection among all of them which was as freely expressed as it was unusual.

EFFECTS OF FOREST FIRES ON FOOD AND GAME FISHES

THE *Fisheries Service Bulletin* calls attention to the fact that everyone is more or less familiar with the loss of valuable timber sustained each year from forest fires, but there are other serious losses of valuable natural resources from this cause that have received but comparatively little attention. We refer to the wild life of the woods and streams, and particularly to the game and food fishes. Based on a monetary valuation the loss of wild life from forest fires may appear insignificant compared with the loss of timber, but when we consider that the U. S. Forest Service estimates that some 6,000,000 people annually visit our natural forests, many or most of them interested in the fish and game, we become aware to some extent of the importance of the wild life of our forests. Any game and fish commission or conservation commission will be able to vouch for the real value of good fishing to a community.

In line with the growing tendency to place a large portion of the responsibility of conserving our natural resources on those who reap the greatest benefits therefrom, it seems proper to invite the attention of those persons who find pleasure and healthful recreation in fishing in the waters of our forests to the destructive effects of forest fires on the fish. There is a deplorable lack of reliable information and very few recorded observations on the subject. A few of the most immediate effects detrimental to fish life that may be expected to follow forest fires are a sudden rise in the temperature of the water, a lowering of its oxygen content, a change in its chemical properties, and destruction of shade. The slightly acid condition natural to most forest streams, and recognized as suitable for trout, is changed to alkaline from the ash deposited therein. A large amount of ash in the water may be expected to have a deleterious mechanical effect on the fish aside from the chemical changes.

These are but a few of the more obvious and immediate results of fires, and they take no cognizance of the most far-reaching though not immediately apparent effects that probably occur—the destruction of food, increased turbidity, decreased protection against floods and drought, etc. Reliable information on the subject is meager, though an appreciation of the loss of fish from this cause and a record of intelligent observations thereon are of importance. It will be appreciated if persons having knowledge of such occurrences will communicate it to the Bureau of Fisheries.

CONFERENCE ON WORLD METRIC STANDARDIZATION

No less than twenty-seven national scientific societies were represented in the Conference on World Metric Standardization which was held at the Carnegie Institute of Technology on September 6, simultaneously with the Pittsburgh meeting of the American Chemical Society. Dr. E. C. Bingham, of Lafayette College, presided, and opened the discussion.

The conference was called because it was deemed advisable to take cognizance of the organized opposition to the spread of the metric system which has developed in certain

quarters.[1] The delegates, however, devoted very little time to consideration of the relative merits of the metric system and the English system, since the superiority of metric measurements seemed to be conceded by every one present. Discussion turned rather on questions of the best methods of furthering general adoption of the metric system. Representatives spoke on behalf of such diverse fields as architecture, astronomy, chemistry, civil engineering, education, electricity, medicine, optometry, pharmacy, physiology, public health, and other branches of pure and applied science.

Physicists, chemists and pharmacists, on the one hand, reported that the metric system is already in general use and the battle won as far as their portions of the field are concerned. Representatives of the medical societies, on the other hand, reported a surprising inertia on the part of physicians to make use of gram and milligram units instead of apothecaries' weight in writing prescriptions, although only metric units are used in recent editions of the pharmacopœia. Better instruction and drill in the actual use of metric units was demanded of all schools, and in particular of the medical schools.

The civil engineers and the architects stand apparently in a passive attitude, content to continue in the use of the English system until a demand on the part of the public indicates a greatly reduced inertia with reference to the abandonment of inches, feet and miles.

As far as the writer knows, this is the first conference at which the relative merits of *gradual* adoption of the metric system *vs.* compulsory universal adoption have been debated by a group of scientific men who have then gone definitely on record as favoring the policy of gradual adoption. The opposition has proceeded upon the assumption that the change to the metric system must be completed suddenly, or else it can not be made at all. As a result they conclude that the change must be made at an appalling cost to industry. The conference went on record unanimously as of the opinion that the gradual introduction of the metric system is practicable. The question of how legislation may be used to assist in bringing about the gradual change was not taken up at this conference.

[1] See this journal, June 23, 1922, "Are Scientists Encouraging Popular Ignorance?"

Dr. W. A. Noyes read a paper by Dr. T. C. Mendenhall representing the National Academy of Sciences. In it Dr. Mendenhall combated with historical facts many of the fallacious arguments which have recently been advanced against the spread of the metric system. The paper will appear in full in SCIENCE.

Formal action was taken by the conference on four points, as follows:

1. *Voted*, that it is the sense of this meeting that we favor the gradual adoption of the metric system wherever practicable.

2. *Voted*, that this body take up with the United States Bureau of Education and other agencies, a plan for the better teaching of the metric system in the schools.

3. *Voted*, that the United States secretary of commerce be asked to secure information as to the extent to which the metric system is actually used at present in those countries which have made its use compulsory by law; and also in those countries where its use is not obligatory.

4. *Voted*, that the system of double-marking all goods be encouraged. (This vote was adopted by only a small majority.)

W. V. BINGHAM,
Secretary of the Conference
CARNEGIE INSTITUTE OF TECHNOLOGY

ACTIVITIES OF THE ROCKEFELLER FOUNDATION

THE *Journal* of the American Medical Association reports that the minister of education has accepted on behalf of the Japanese Government an invitation from George E. Vincent, president of the Rockefeller Foundation, New York, to name and send a commission of Japanese medical scientists to visit the medical institutions of the United States and Canada, as guests of the Rockefeller Foundation. This idea originated from the success that attended the visits to America of similar commissions from Great Britain, Brazil and Belgium. The commission will consist of four or five men, well known as representatives of the important branches of medical science and of the principal medical universities and institutes of the

country. The spring of 1923 has been selected as the most suitable time for this visit, which will last about three months.

According to the agreement between the Rockefeller Foundation and the government of Honduras, a hookworm disease section and a public health department were organized in that country. The Foundation will bear 66 per cent. of the expenses during the first year and 34 per cent. during the second, and the Honduras government will assume all expense from the third year on.

In a report from Geneva, August 17, it was stated that the hygiene committee of the League of Nations had decided to accept the offer of the Rockefeller Foundation, amounting to the sum of $60,000 a year for three years, to allow an interchange of staff in the public health services of various countries, and a sum of $30,000 yearly for five years for the development of an international office for distributing information as to epidemics. After the necessary documents are signed, the plan will be put into action at once, and the interchange of staff will begin in October. For a period of two weeks, functionaries of various nationalities—a Bulgarian, two Belgians, two Czechs, five Italians, five Poles, five Russians and two Serbians—will pursue an intensive short course at Brussels, following which they will spend two months in the public health services of different countries.

SCIENTIFIC NOTES AND NEWS

SIR ERNEST RUTHERFORD, Cavendish professor of physics at the University of Cambridge, has been elected president of the British Association for the Advancement of Science in succession to Sir Charles S. Sherrington. The meeting next year will be at Liverpool, and it is expected that the meeting the following year will be in Canada.

PROFESSOR W. L. BRAGG, of Manchester University, who, together with his father, Sir William Bragg, was awarded the Nobel Prize for physics in 1915, delivered on September 6 the lecture in Stockholm as prescribed by the statutes of the Nobel Institution.

ENGINEER VICE-ADMIRAL SIR GEORGE GOODWIN, K. C. B., late engineer-in-chief of the fleet, and Dr. James Colquhoun Irvine, C. B. E., F. R. S., vice-chancellor and principal of St. Andrews University, have been appointed to be members of the advisory council to the committee of the privy council for scientific and industrial research.

DR. WILLARD ROUSE JILLSON, director and state geologist of the Kentucky Geological Survey, was elected an honorary member of the Natural Gas Association of America at its recent meeting in Kansas City.

DR. HENRY FAIRFIELD OSBORN, president of the American Museum of Natural History, has sailed from Seattle on the *President Grant* of the Admiral Line for Yokohoma. From Yokohoma Dr. Osborn will go to Korea and thence by rail to Peking to the headquarters of the museum, where he will meet the members of the Third Asiatic Expedition. During his stay in Peking, Dr. Osborn plans to make a trip to the edge of the Gobi Desert, where the expedition has found beds of Cretaceous and Tertiary deposits. From Peking, he will go to the Philippine Islands and from there to India to visit the fossil-bearing formations in the Siwilik Hills, where Mr. Barnum Brown is collecting for the museum.

AT the Pittsburgh meeting of the American Chemical Society, the Division of Industrial and Engineering Chemistry elected D. R. Sperry, chairman, W. A. Peters, Jr., vice-chairman, E. M. Billings, secretary, and the following were elected members of the executive committee: W. F. Hillebrand, Edward Mallinckrodt, Jr., F. M. deBeers, A. Silverman, H. C. Moody, and C. E. Coates.

NORMAN SNYDER, a member of the scientific staff of the Radio Laboratory of the Bureau of Standards, left the bureau June 1 for a leave of absence of several months to work in the research laboratory of the General Electric Company at Schenectady on electron tube problems.

F. W. STAVELY, Ph.D. (Chicago, '22), has accepted a position with the Firestone Tire and Rubber Company at Akron, Ohio.

Dr. C. S. Leonard, who has for the past year been working with Dr. A. S. Loevenhart at the University of Wisconsin upon synthetic arsenicals, has accepted a position as a pharmacologist in the Hygienic Laboratory, U. S. Public Health Service, Washington, D. C.

The following have joined the staff of the research laboratory of the Eastman Kodak Company: Dr. Helge Schibsted, formerly with the Atmospheric Nitrogen Company; Clyde Brockett, Massachusetts Institute of Technology, 1922; Alasco Burgess, Bates College, 1922; D. Henry Harris, Massachusetts Institute of Technology, 1922; Roger P. Loveland, Grinnell College, 1919.

Dr. Lewis M. Hull, who for several years has been engaged in studies of electron tubes in the radio laboratory of the Bureau of Standards, has resigned to accept a position as director of research of the Radio Frequency Laboratories, Inc., of Boonton, N. J.

Miss Gudrun Carlson, assistant in the department of foods and cookery at Teachers College, has been appointed home economics expert in the publicity department of the Institute of American Meat Packers.

Mr. Eric R. Jette, who recently completed his work for the Ph.D. in chemistry at Columbia University, has sailed for a year of study in Stockholm. He has an American-Scandinavian fellowship for the year 1922-23.

Dr. Roland E. Kremers has resigned as assistant professor of chemistry in Vanderbilt University, and has returned to the University of Wisconsin, where he will be in residence this year under a National Research Council fellowship. He will work on the peppermint oils and on azulene.

Dr. F. L. Stevens, professor of plant pathology in the University of Illinois, has returned from a summer spent in collecting fungi in British Guiana. Collections were made on the coast and in Demerrara, Essequibo and Potaro Rivers.

Professor C. A. Noble, of the department of mathematics, University of California, has been granted a term's leave of absence, which he will spend in Europe.

Dr. Knud Stephensen, of the Zoological Museum at Copenhagen, known for his studies on the Crustacea, is visiting the scientific institutions of the United States.

Dr. Wilfred T. Grenfell, known for his work in Labrador, has sailed for Europe and will lecture twice in London. Lord Milner will preside at one of these lectures.

At the Pittsburgh meeting of the chairmen and secretaries group of the American Chemical Society, a plan was launched by which Professor E. C. Franklin, of Leland Stanford University, will give a series of lectures before several of the local sections of the society. These will be given near the time of the spring meeting, that is, the latter part of March and the early part of April. The following sections have asked Dr. Franklin to speak before them on this trip: Chicago, Detroit, East Lansing, University of Michigan, Purdue, Cleveland, New Orleans, West Virginia, Pittsburgh, Buffalo, Rochester, Syracuse and Philadelphia. If there are other sections of the American Chemical Society or other scientific bodies who would like to have Dr. Franklin speak before them, information can be obtained by writing to E. M. Billings, Kodak Park, Rochester, N. Y.

Mr. A. Chaston Chapman, F.R.S., honorary treasurer in England of the Pasteur Commemoration Fund, writes to the *British Medical Journal* that a sum of £848 14s. 6d. has been subscribed to this fund, in addition to sums which had previously been sent to France in response to earlier and direct appeals. In accordance with a resolution passed at a recent meeting of the Pasteur Commemoration Committee, presided over by Sir Charles Sherrington, P.R.S., a draft for the above amount is being forwarded to Monsieur Héring, the general treasurer, at Strasbourg, with an intimation that should the amount prove more than the French committee desires to expend upon the monument the excess should be devoted to some other form of permanent memorial of Pasteur in the University of Strasbourg.

The Prince of Wales has consented to unveil on November 3 the memorial tablet of the late Professor Sir William Ramsay which is being

placed in Westminster Abbey. The tablet has been executed by Mr. Charles L. Hartwell, A.R.A., and was exhibited at the Royal Academy this summer.

Dr. Horatio R. Storer died at his home in Newport on September 18, at the age of ninety-two years. Dr. Storer was a distinguished gynecologist, who, after an infection from an operation, retired from active practise in 1872. He continued to be active in many scientific movements, having been the founder and life-president of the Newport Natural History Society.

UNIVERSITY AND EDUCATIONAL NOTES

By the will of Dr. William S. Halsted, lately professor of surgery in the Johns Hopkins University, the residue of his estate, valued at approximately $100,000, is left to the university, subject to the payment annually to his widow of five per cent. of the value of the legacy. The bequest is to be devoted to research in medicine, preferably in surgery.

On September 6, the old chemical laboratory of the Massachusetts Agricultural College was destroyed by fire. The building was one of the oldest on the campus, having been built in 1867, and occupied more or less completely by the department of chemistry since that time. About four thousand dollars' worth of apparatus, including all the platinum, was recovered. A new laboratory was provided for during the last legislature by an appropriation of $300,000. This building is now being erected and will be ready for occupancy in August, 1923.

By action of the board of trustees of the Ohio State University on June 19, supplemented by further action on July 11, the College of Homeopathic Medicine, which had been a part of the university since 1914, was abolished.

Dean D. W. Morehouse, for twenty-two years professor of physics and astronomy at Drake University, Des Moines, Iowa, has been elected dean of the liberal arts college and acting president. President Arthur Holmes is on leave of absence, his resignation taking effect on June 1, 1923. Dr. Morehouse was awarded the Donahue Comet Medal in 1908 for discovery of the Morehouse comet.

Dr. W. N. Steil, of the University of Wisconsin, has been appointed professor of botany in Marquette University, the former department of biology having been divided into the separate departments of botany and zoology. Dr. Edward J. Menge, former director of the department, automatically becomes director of the department of zoology.

Dr. Martin C. E. Hanke has been appointed instructor in physiological chemistry at the University of Chicago.

W. J. Kostir, who during the past year has been instructor in zoology at Columbia University, returns this fall to Ohio State University as assistant professor of zoology and entomology.

Dr. L. E. Miles, of the Mississippi Plant Board, has become associate professor of plant pathology and associate plant pathologist in the Alabama Polytechnic Institute and Experiment Station.

Professor H. R. Dean, of the University of Manchester, has been appointed professor of pathology at the University of Cambridge in succession to the late Sir German Sims Woodhead.

Captain George Paget Thomson, lecturer in mathematics at Corpus Christi College, Cambridge, has been appointed to the chair of natural philosophy in the University of Aberdeen, in succession to Professor C. Niven, recently retired. Mr. Thomson, who was unanimously elected by the court out of seventeen applicants, is the only son of Professor Sir J. J. Thomson, master of Trinity, Cambridge. He has had a distinguished academical career, and is only thirty years of age.

DISCUSSION AND CORRESPONDENCE

GROWTH OF PLANTS IN ARTIFICIAL LIGHT FROM SEED TO SEED

During the past winter the author has succeeded in producing good seed from plants

grown in artificial light entirely. Since no reference to the growth of plants from seed to seed without sunlight has been found in the literature this preliminary report of the first successful attempt may be of use to plant breeders and agronomists in northern regions.

A great variety of plants including several varieties of wheat, oats, barley, rye and potatoes, buckwheat, lettuce, beans, peas, clovers, radishes, flax and a number of common weeds were grown from seed to seed entirely in artificial light. The seed produced was of good quality, full of starch, and germinated well.

Light for the experiment was obtained from tungsten filament nitrogen filled lamps which were burned for twenty-four hours each day. The lamps are rated to burn 1,000 hours but they averaged 3,000-4,000 hours under continuous use. One set of lamps was found to be more than sufficient to produce an ordinary crop such as the cereals, since the time to head is much decreased by continuous illumination. Spring wheats produced ripe seed in about 90 days. At this rate it ought to be possible now to grow three generations from a cross within one year. The growth of valuable plants in artificial light should be of considerable advantage in northern regions where the light in winter is of short duration and low intensity.

All of the plants tested, except cabbage, have bloomed and each variety does not seem to require any particular period of illumination to cause blooming as found by Garner and Allard.[1]

Four ranges of light intensity were used and a number of plants bloomed in all of them, although the illumination was continuous. The tests were performed in three unheated basement rooms. It was unnecessary to supply any heat other than that produced by the lamps even in the coldest winter weather. For cereals the temperature was controlled automatically at 14° C. by blowing in cold outside air. The energy used in heating the ordinary greenhouse in Minnesota during the winter would be ample for both light and heat in such experiments as these since nearly all the energy of the light finally goes to heat and thus is made to serve a double purpose.

R. B. Harvey

University of Minnesota

[1] Garner, W. W., and Allard, H. A.: *Jr. Agr. Res.*, 18: 553-606: 1920.

THE PREPARATION OF CLEAR BEEF AGAR

A clear beef agar with a p_H reading from 6.6 to 7.0 being desired and the usual method for the preparation of such media proving unsatisfactory, inasmuch as a cloudiness often developed in the cleared agar on sterilization, the following procedure has been adopted and has proved uniformly reliable.

The formula is as follows:

Beef extract (Liebig's)	3 grams
Peptone ("Bacto")	10 grams
Sodium chloride	5 grams
Agar Agar	15 grams

These ingredients are dissolved in one liter of distilled water by flowing steam. As suggested by the directions for the preparation of beef bouillon, given by James McIntosh, M.D., and William A. M. Smart, B.Sc.Land.,[1] the resultant nutrient agar is adjusted to a p_H of about 8.2 with an approximately normal solution of sodium hydroxide. After cooling to 45°-50° C., the beaten whites of two fresh eggs are added. Soluble egg albumin powder may be substituted for the fresh eggs, 5 grams beaten up in 50 cc. of distilled water proving satisfactory. If more than one liter is being made, the beaten white of one egg or a proportional quantity of egg albumin powder should be used for each additional liter. After mixing thoroughly by pouring from one container into another, the agar and egg are autoclaved for 15 minutes at 15 pounds pressure, filtered through paper or, preferably, through absorbent cotton by suction, and the filtrate adjusted to the desired p_H with an approximately normal solution of hydrochloric acid. It is then autoclaved for 5 minutes at 15 pounds pressure to insure the complete precipitation of any fine particles remaining in suspension and filtered through paper. After tubing, it is finally sterilized for 20 minutes at 15 pounds pressure. This beef agar remains

[1] James McIntosh and William A. M. Smart: "The Adjustment of the Reaction of Bacteriological Media," *Lancet*, Vol. CXCVII, No. 5017.

clear after sterilization and has given excellent results as a bacteriological medium.

Franklin W. Marsh
U. S. Department of Agriculture

THE EFFECT OF FEEDING VELVET BEANS TO PIGEONS

Three groups of three mature pigeons each were fed as follows:

Pen I: Ground velvet beans.

Pen II: Ground velvet beans plus aqueous extract of rice bran.

Pen III: Ground velvet beans plus aqueous extract of rice bran plus 10 per cent. butterfat.

The beans were fed dry and at the start were eaten readily. Pens II and III were given an aqueous extract of rice bran as the sole source of drinking water.

On the second day after feeding the beans, all birds showed ruffled feathers and a drawn-up, sleepy appearance. On the fourth day, one bird in Pen I and one in Pen II died. The remaining birds were in very poor condition. The loss in weight averaged about 80 grams.

Check birds receiving polished rice made slight gains during the same period, and were apparently in thrifty condition. On the fourth day the feed was changed to polished rice in all pens. One bird in Pen III was too weak to eat and was hand-fed on polished rice. Recovery was rapid in all cases.

Two pigeons were then fed ground velvet beans from another source. They rapidly developed the appearance of the birds in the former test. Both died on the eighth day.

Ground velvet beans were forced into the crops of two pigeons that had developed symptoms of severe polyneuritis. A decided improvement in condition was noticed. The birds died, however, on the following night in one case and on the second day in the other.

An aqueous extract of velvet beans furnished as the sole source of drinking water to pigeons receiving polished rice, apparently delayed the onset of polyneuritis, but did not entirely prevent it. The difference in appearance of the birds receiving the extract and of check birds receiving polished rice alone was striking. The feathers of the former remained smooth and glossy, while those of the latter soon became dry and rough looking. These results seem to indicate at least a small amount of water soluble B in the beans.

An effort will be made to ascertain the cause of the ill effect.

W. D. Salmon
South Carolina Experiment Station,
Clemson College, S. C.

A CHEMICAL SPELLING MATCH

A unique modification of the old-time spelling bee was staged at the West Virginia University last May with rather remarkable success.

At the suggestion of the writer the chemical faculty of the university arranged to hold a contest among the 376 students taking the course in general inorganic chemistry, and this contest was to be a public match for the spelling of chemical formulæ of such compounds as are ordinarily included in a first year's college course in chemistry.

These students are normally divided into sixteen quiz sections, and it was evident that so many could not be brought on the floor at the same time for spelling. Therefore, eight preliminary matches were held at seven o'clock in the evening of the final match, where two sections, in charge of two instructors, spelled against each other, and then a number chosen from each of these groups, representing one out of every eight students, who became eligible to the final match.

The preliminaries lasted about one hour, after which all the students assembled in the armory and the winners lined up for the final contest. Professor Samuel Morris pronounced the words, and three well-known chemists, not connected with the department, acted as judges. For example, ortho phosphoric acid was given, and the student whose turn it was replied by saying "H_3PO_4."

Upwards of 700 formulæ were prepared for the instructors' use at the preliminaries, and then 50 to 60 additional formulæ in case of emergency for the final match. As a prize, Mr. J. F. Cadden, the winner, was presented with a copy of Mellor's "Modern Inorganic Chemistry." The last five students to spell down were presented with attractive certificates bearing the university seal.

A great deal of enthusiasm and rivalry be-

tween quiz sections was manifested, and the different sections came as units to boost their representatives. The students had had three or four weeks in which to prepare for the contest, and nearly all of them had been working hard for it. Our instructors are all agreed that the students participating derived great benefit from this match.

In addition to these benefits, the contest brought out the fact that our chemical nomenclature is not yet above reproach. A few instances of ambiguity might be cited: Sodium thiosulphate, $Na_2S_2O_3$, is sometimes named sodium hyposulphite and so labelled by a few manufacturers of chemicals. The latter name, however, is represented by the formula $Na_2S_2O_4$. Potassium fluosilicate and potassium silicofluoride are both used to represent the same substance. Potassium sulphocyanide and potassium thiocyanate are two names in use for KCNS. Then, again, we say hydronitric acid, or triazoic acid, or azoamide, when we mean a substance with the composition N_3H.

If these spelling bees were to be adopted by a considerable number of educational institutions it would doubtless tend to unify chemical nomenclature so that finally we should have one name only to represent a chemical compound having a definite composition. Spelling matches of this sort could also be profitably arranged between classes in organic chemistry, mineralogy and perhaps other departments of science. The contests appeal to students because they combine the elements of sport and competition. The benefits derived therefrom are incalculable, and we are now planning to make the chemical spelling match an annual event at the West Virginia University.

C. A. JACOBSON

MORGANTOWN, WEST VIRGINIA

SCIENTIFIC BOOKS

Proteins and the Theory of Colloidal Behavior. By DR. JACQUES LOEB, member of the Rockefeller Institute for Medical Research. New York: McGraw-Hill Book Co., 285 pp. 1922.

IN this volume the author has collected the results of his extensive investigations upon the properties of protein solutions and has attempted to found upon them a general theory of colloids. The book falls naturally into two sections. The main argument in the first half is that proteins are amphoteric electrolytes and that consequently, when hydrogen ion concentrations are duly measured and considered, proteins are found to combine with acids and alkalies according to the stoichiometrical laws of classical chemistry. This argument is illustrated and supported by numerous tables and diagrams. In the second part of the book the conclusion is established that all of the experimental results recorded can be logically explained upon the basis of Donnan's theory of membrane equilibria.

The far-reaching significance of the author's contentions may be summarized in the statement that, if justified, they dispose of colloid chemistry as a special branch of the science, with laws different from those of general chemistry. This does not, as is pointed out in the preface, detract from the importance of colloidal behavior for physiological and technical problems, but it completely changes the theoretical treatment of the subject.

A revolution in our current conceptions of colloidal solutions is hereby threatened, equal in importance to that brought about by van't Hoff and Arrhenius a generation ago in the field of crystalloidal solutions, and it seems probable, from certain reviews that have already appeared, that the battle between the new and the old points of view will be waged with equal bitterness. It is interesting to note in this connection that the veteran fighter Armstrong, now president of the Society of Chemical Industry in England, went out of his way in his recent Messel Memorial Lecture at Glasgow to refer to Loeb's "praiseworthy efforts to raise the character of the proteins from mere indeterminate lumps of jelly to a status of definite materials behaving in a simple and definite, orderly manner, if only put under comparable conditions." Since, however, he indulged in the course of the same address in his customary diatribes against the Scandinavian Ikon Arrhenius and his High Priest Ostwald, remarking that "hydrogen ion concentration is pure gibberish," his conversion to Loeb's

theory is obviously incomplete. As he so appositely puts the case himself: "We all have partially permeable intellects."

At this stage, indeed, it is altogether premature to express an opinion as to the outcome of the struggle. What is certain is that Loeb has made, in this volume, a brilliant thrust which his adversaries will find it difficult to counter. There are many points of detail in his experimental work which will curdle the blood of any analytical chemist, yet it appears on close examination that the errors introduced are, after all, insufficient to affect the main issue. The opponents of Loeb's views, in any case, cannot restrict themselves to attacking the weak points of his presentation; he has already succeeded so far as to put them definitely on the defensive. To quote from his own preface: "Any rival theory (of colloidal behavior) which is intended to replace the Donnan theory must be able to accomplish at least as much as the Donnan theory, *i. e.*, it must give a quantitative, mathematical and rationalistic explanation of the curves expressing the influence of hydrogen ion concentration, valency of ions, and concentration of electrolytes on colloidal behavior; and it must explain these curves not for one property alone but for all the properties, electrical charges, osmotic pressure, swelling, viscosity, and stability of solution, since all these properties are affected by electrolytes in a similar way."

This quotation may be supplemented by another, from the final page of the book, indicating the importance of Loeb's work outside of chemistry. "If Donnan's theory of membrane equilibria furnishes the mathematical and quantitative basis for a theory of colloidal behavior of the proteins, as the writer believes it does, it may be predicted that this theory will become one of the foundations upon which modern physiology will have to rest."

Every so-called colloidal chemist will evidently be forced to read Loeb's book in self-defense. Those also who are only indirectly interested in colloidal phenomena cannot fail to find it stimulating.

James Kendall

SPECIAL ARTICLES

MOSAIC CROSS-INOCULATION AND INSECT TRANSMISSION STUDIES

Whether or not the plant disease known as mosaic is transmissible to plants of different orders, and the rôle of insects as agents in such transmission, are questions of fundamental importance. It is generally held that mosaic of the Cucurbitaceæ, Solanaceæ and Leguminaceæ are all quite specific and with few exceptions transmissible only to species within the same family. Certain mosaic diseases have been described indicating that even among species within the same family there may be two or more types of the disease. Allard[1] in 1916 described a specific mosaic disease on *Nicotiana viscosum* distinct from the mosaic disease of *Nicotiana tabacum*. Jagger[2-3] in 1917 and 1918 reports three specific mosaic diseases of the cucurbits. The tendency has thus been to divide mosaic into types which are distinct in their host range.

As opposed to the evidence indicating that there are a number of types of mosaic which are specific to a narrow host range, we have evidence showing that mosaic will cross to species belonging to other families and orders. Jagger[4] in 1918 published results of cross-inoculation studies where he succeeded in transferring mosaic from the Cucurbitaceæ to species of two other families of the Order Campanulales. Doolittle[5] has shown that mosaic of cucumber is transmissible to *Martynia louisiana,* a species belonging to the Order Polemoniales.

Cross-inoculation experiments by the writer have shown that the mosaic diseases of the Cucurbitaceæ, Solanaceæ and Leguminaceæ are inter-transmissible. Four petunia plants inoculated with mosaic from crookneck squash became infected while an equal number of checks remained healthy. The inoculations were made by inserting mosaic tissue into the stem with a sterile scalpel. An experiment in which juice from mosaic plants was inoculated hypo-

[1] *Journn. Agr. Research,* 7: 481-486, 1916.

[2] *Phytopathology,* 7: 61, 1917.

[3] *Phytopathology,* 8: 74-75, 1918.

[4] *Phytopathology,* 8: 32-33, 1918.

[5] *U. S. D. A. Bull.* 879, 1-69, 1920.

dermically resulted in 100 per cent. infection. Using this method, four crookneck squash plants were inoculated with mosaic from tomato, and four with mosaic from tobacco. All of these plants became infected. Similarly, a tobacco and two tomato plants were inoculated with juice from mosaic crookneck squash leaves and became infected. The number of plants kept as checks greatly exceeded the number of inoculated plants. All checks remained healthy. In an attempt to cross-inoculate tomato with mosaic from crookneck squash by the hypodermic needle method, two out of five plants became infected while the ten checks all remained healthy. In another experiment where mosaic crookneck squash leaf tissue was inserted into the midribs of five tobacco plants, the result was 100 per cent. infection. At the same time five tobacco plants were similarly inoculated with mosaic cucumber tissue and one of the five became infected. These inoculations were made using a sterile flamed scalpel. In order to further check whether or not the inoculations were being made under sterile conditions, healthy leaf tissue was inserted into the midribs of ten tobacco plants. In addition, 30 plants were kept as checks. No mosaic developed either on the inoculated or on the uninoculated checks. An attempt to inoculate tomatoes with mosaic from catnip, *Nepeta cataria,* resulted in three of the five plants inoculated becoming infected while an equal number of checks remained healthy.

The investigations made by the writer with mosaic of the legumes have been mainly with cow pea, *Vigna Catjang.* Although the cow pea has not been reported susceptible to mosaic, this species has been found susceptible under greenhouse conditions. Symptoms include mottling and distortion of the leaves, and stunting of the whole plant. Inoculation by means of transferring aphis (species undetermined) from the mosaic plants to healthy plants was shown clearly that this mosaic is a transmissible disease. Two pots containing 38 cow pea seedlings were infested with aphis from the mosaic cow pea plants and were placed in insect proof cages. One hundred per cent. infection occurred in both pots while all checks remained healthy.

In addition to aphis being carriers of mosaic, numerous experiments have shown that the mealy bug (*Dactylopus sp.*) also transmits this disease. This has been found especially true where mealy bugs caused mosaic infection of cow peas and soy beans. Cross-inoculation experiments using mealy bugs which had been transferred from mosaic infected solanum and cucurbit plants to healthy cow pea seedlings, have resulted in infection in both cases. Experiments have shown that soy bean plants are susceptible to mosaic from cow peas where mealy bugs served as carriers. Mealy bugs with a portion of the mosaic plant on which they were feeding were transferred to the pot containing the seedlings. The result of an experiment in which mealy bugs from a mosaic crookneck squash plant were transferred to two pots containing a total of 33 cow pea plants gave 100 per cent. infection. All checks remained healthy. A pot of cow pea plants was inoculated by means of mealy bugs from mosaic infected egg plant and of 38 plants 100 per cent. became infected. At the same time aphis from mosaic potato were transferred to another pot containing 36 cow pea seedlings, 28 of which developed the disease. Out of 60 plants held as checks no case of mosaic has appeared. Mealy bugs were transferred from mosaic infected cow pea to soy bean seedlings with the results that a large per cent. of the soy bean plants developed mosaic.

Data and observations in the greenhouse indicate that mealy bugs may transmit mosaic to solanums. Two tobacco plants and one tomato plant have thus been infected with mosaic from crookneck squash through the agency of mealy bugs.

The results obtained indicate that the mosaic with which we are working is inter-transmissible between species of Cucurbitaceæ, Solanaceæ and Leguminaceæ. To what degree this will hold true under field conditions has not been determined. Judging from observations, the writer believes that infection with mosaic is to a large degree determined by the growth condition of the plant. Experiments testing this point have shown that the optimum condition for mosaic infection is an unchecked, vigorous growth of the plant. Inoculations of mosaic within the Solanaceæ or within the Cucurbita-

ceæ have, as a rule, been more easily accomplished than the cross-inoculations between members of the Solanaceæ and members of the Cucurbitaceæ. Successful cross-infections between members of different families are more easily obtained with plants growing under very favorable conditions than with plants growing under unfavorable conditions.

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SPERMATOGENESIS OF THE GARTER SNAKE

Up to the present no work has been published on the spermatogenesis of the snakes. The only Reptilia which have been studied in any detail have been the lizards, and the recent work of Dalcq and Painter has definitely pointed out that an accessory element exists in this group. The work on the spermatogenesis of this species of snake (*Thamnophis butleri*) has progressed far enough to make it advisable to publish a few of the details, although the work has not yet been completed.

The species on which this study is being made was collected in the vicinity of Ann Arbor, Michigan, and was identified by Drs. A. G. Ruthven and F. N. Blanchard. It has one of the narrowest ranges of any of the garter snakes but is abundant in that locality.

The material has been fixed in Flemming's strong and Flemming's strong plus .5 per cent. urea at both room temperature and cold, and in Allen's modification of Bouin. The best results have been obtained with cold Flemming plus urea, fixed for twenty-four hours, sectioned at six micra and stained with Heidenhain's Iron Hæmx. by the short method of Lee.

The material shows thirty-seven chromosomes in the spermatogonial equatorial plates in the best counts and this is what would be expected from a study of the spermatocyte divisions. There is a border of large bent rod shaped chromosomes and an inner group of short rods and round chromosomes.

In the late prophase and side views of the equatorial plate of the first spermatocytes the accessory elements form a tripartite body. Polar views of the first spermatocyte show seventeen autosomes and either one or two accessory chromosomes depending on the way the plate is turned. At the first division, the tripartite body divides, two parts going to one pole and one to the other, the double part remaining more or less fused. A polar view of the first spermatocyte shows five quite large bivalents, two of which are slightly smaller than the other three, eleven medium sized and two microsomes, making eighteen as the haploid number. If the double accessory happens to be turned toward the observer, one of the three large ones gives the double appearance. There is little indication of an earlier division of the accessory elements though at times the double one may be seen lying closer to the centrosome, indicating that it has divided earlier. The first division is the differential division, the two daughter cells receiving the following: one, seventeen autosomes and the double accessory, and the other, seventeen autosomes and the single accessory.

The second spermatocyte division then becomes an equational one so far as the accessory chromosomes are concerned and give rise to two classes of spermatozoa.

Oogonial counts have not yet been made to determine whether the single or the double is the X chromosome, but it might be expected, in light of what has been found in the lizards by Painter, that the double one is the X and the single the Y and that oogonial counts should yield thirty-eight chromosomes. It would seem in this species of snake, at least, that the accessory chromosomes are found as three separate ones in the spermatogonia, which bears out what Painter has already described for the lizards.

Examination of some slides of snake testis of an unknown species has revealed a condition of the chromosomes more like the lizards as described by Painter. This material shows in the first spermatocyte division equatorial plates with approximately nine very large and eleven very small chromosomes as the haploid number. Before the complete results are published, a comparative study of other genera and families will be made in order to determine whether the behavior of the accessory chromosomes in snakes falls in line with what Painter has already described for lizards.

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